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The Many Uses of the Atom

Waldemar Kaempffert

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HEADLINE SERIES

THE MANY USES OF THE ATOM,
by Waldemar Kaempffert Page 3

The atom bombs dropped on Hiroshima and Nagasaki have come to symbolize the acquisition by man of unlimited power to destroy life on our planet. Yet man has shown that the atom can also be used to create life. This concept of atoms for peace rouses the hopes of underdeveloped lands, stirs the imagination of all human beings who yearn to end the threat of nuclear war, and offers a common ground for cooperation between the Soviet bloc and the non-Communist world. This book answers the most significant questions the layman asks today about the atom.

TALKING IT OVER,
A Discussion Guide Page 55

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The Author

WALDERMAR KAEMPFFERT, science editor of *The New York Times* since 1931, has acquired a world-wide reputation for his skill in making scientific knowledge understandable to the layman. Before joining *The New York Times* he had been managing editor of *The Scientific American,* editor of *Popular Science Weekly,* and first director, appointed in 1928, of Chicago's Museum of Science and Industry.

In addition to the contributions he makes to his weekly "Science in Review" department published in the Sunday *Times* Mr. Kaempffert has published several books, notably *Science Today and Tomorrow* and *Explorations in Science.* In 1954 he received the Kalinga prize for science writing, established by UNESCO on the basis of an annual grant from the Kalinga Foundation Trust in India. Under the terms of this award he visited India, speaking on the progress of science in the United States and its consequences to the world, and studying Indian science.

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The Many Uses of the Atom

by Waldemar Kaempffert

THE YEAR 1945 WAS A MILESTONE IN THE social and scientific history of man. On July 16 of that year an experimental atomic bomb was detonated in New Mexico. On August 6 and 9, 1945, respectively, two more atomic bombs destroyed the Japanese cities of Hiroshima and Nagasaki and blotted out a hundred thousand lives.

The atomic age had dawned amid the crash of falling buildings, and fire, and death. Mankind had been endowed with the power either to expunge the civilization it had slowly and painfully developed or raise it to undreamed-of heights. A new source of energy had been tapped—the primal energy which causes the stars to glow and the sun to blaze in a glory that symbolizes life.

Nature of Matter

Although the bomb burst on the world suddenly, it was the consequence of an age-old effort to understand matter. For centuries thinking men have been asking, What is matter? The obvious way to answer this question is to pound or grind a piece of matter—a rock, a metal—into smaller and smaller pieces. In the end we have—what? A powder—fine particles of the original piece. Evidently matter must be composed of something finer than the finest particles that can be obtained by subdivision.

There was nothing for it but to speculate as the Greek philosopher Demokritos did about 2,500 years ago. Out of his speculating came the concept of the smallest possible unit of matter, the concept that everything in the universe was composed of hypothetical, indivisible, indestructible atoms. This was a fruitful concept. Modern chemists developed it and finally reached the conclusion after much experimentation and analysis that there are 92 different kinds of matter in the universe—92 different kinds of atoms. At the top of the list stood hydrogen, lightest of all, and at the bottom stood uranium, the 92nd and the heaviest.

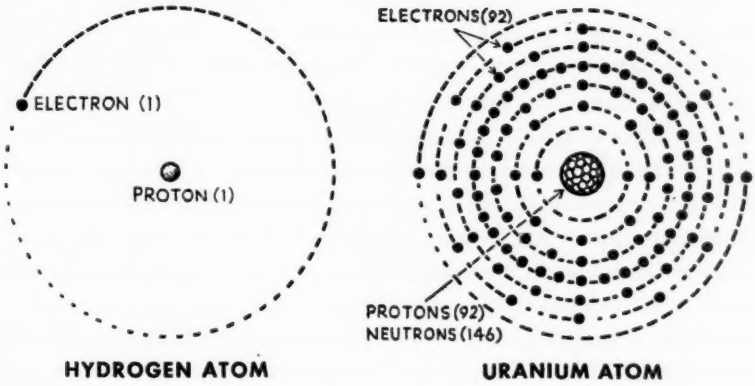
What Is the Atom?

This concept still has its uses, although it was shattered by the discovery of radioactivity in 1896 by Henri Becquerel and later of radium and other radioactive elements. Radium emitted three kinds of rays, which were designated by the Greek letters alpha, beta and gamma. The alphas proved to be helium; the betas were found to be electrons; the gammas were like X-rays but more penetrating.

An electron (beta particle) has only 1/1840 the mass of a hydrogen atom. So an atom was not the smallest hypothetical indivisible unit of matter. Moreover, the electron could be regarded as a bit of matter or as a bit of electricity. A current in a wire turned out to be a flow of electrons, a flash of lightning, a gush. At last, science knew what electricity was. The atom as a whole ceased to be the simple, hard, ball-like, ultimate unit it was supposed to be. It is now known to be the most complicated of structures—so complicated that it may never be perfectly understood.

Physicists think of the atom as a kind of submicroscopic solar system. In the center is the nucleus, often likened to the sun, and around the nucleus revolve electrons, like planets. This structure is nearly all empty space, just as the solar system is nearly all empty space. Tables, chairs, lamps, seem very hard and solid; yet they are composed of atoms in which smaller, fundamental particles are sparsely distributed.

ATOMS



HYDROGEN ATOM URANIUM ATOM

Protons and Neutrons

Physicists now believe that the nucleus of an atom is composed of protons and neutrons. A proton is simply the heart of a hydrogen atom; it carries a positive charge of electricity. A neutron carries no charge at all; it is neutral, as its name implies. The complex nucleus, composed of positive protons and neutral neutrons, is therefore positive. Around the nucleus revolve and leap electrons, which are negatively charged. As every schoolboy knows, electrical positives and electrical negatives attract each other, but positives repel positives and negatives repel negatives. If an atom as a whole is neutral—that is, if it exhibits no electrical properties—it is because the negative planetary electrons exactly counterbalance the positive nucleus.

One atom differs from another in the number of protons and neutrons in its nucleus. Change the number of neutrons, and we theoretically change one atom into another—base metal into gold, for example. This has been done on a microscopic scale. In the practical large-scale release of atomic energy, base metals are not changed into precious metals but elements are readily changed into others. What was once regarded as the dream of the alchemists is evidently more than a dream.

Many Kinds of Isotopes

Not only do atoms of iron differ from atoms of lead in the number of their protons and neutrons, but atoms of the same element differ among themselves. There are three kinds of hydrogen, chemically indistinguishable from one another yet distinguishable by weight. There are four different kinds of lead, differing in the number of their nuclear neutrons. There are several kinds of uranium, of which the most important for practical purposes are those with weights respectively 233, 235 and 238 times greater than that of hydrogen. These variants of an element are known as isotopes. *Iso* means "same," and *tope* means "place." Same place where? In what is known as the periodic table in which elements are listed according to their masses or weights.

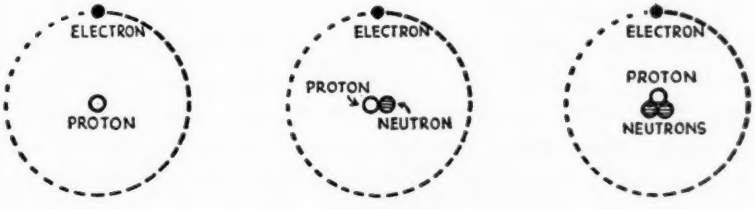
There are about 1,300 isotopes. Every element has its isotopes. Some are stable, that is, unchanging. About 800 are radioactive or unstable, meaning that they change spontaneously into other elements. In the course of 4.6 billion years, half of a given amount of uranium turns into radium and the radium progressively into lead. Both stable and radioactive isotopes have been highly useful in biological, medical and agricultural research and in industry.

The Changeable Genes

With X-rays and radioactive isotopes the biologist has been able to probe deeply into the mystery of heredity by jolting genes, which are to life what the atom is to matter. The genes determine whether we shall be tall or short, blue-eyed or brown-eyed, blondes or brunettes—determine what physical characteristics shall be passed on from one generation to the next. It is possible to change this orderly transmission of physical characteristics by bombarding organisms with X-rays and thus breaking up combinations of genes and creating new ones which result in mutations, that is, departures from the normal type that are hereditary.

Many of the radioactive isotopes emit gamma rays, which are much like X-rays but more penetrating. The gammas can also

THREE HYDROGEN ISOTOPES



PROTIUM
ORDINARY HYDROGEN

DEUTERIUM
HEAVY HYDROGEN

TRITIUM
EXTRA-HEAVY HYDROGEN

jolt the genes into new arrangements and so change the course of heredity. Plant breeders apply this knowledge. It is not likely that the farmer will ever make use of radioactive isotopes directly to produce better and more abundant crops. The plant breeder will do that, and the farmer will buy seeds of modified breeds for cultivation. A new era in agriculture begins, for the geneticist is now able to speed up evolution by compressing into a few years what would otherwise take centuries. Evolution proceeds by mutation, that is, by influencing genes. With radioisotopes the process can be accelerated.

Although radiation genetics is so new that its potentialities are not yet clearly established, Swedish and American plant-breeders have produced some remarkable grains. Varieties of barley have been cultivated with dense heads, with stiff straw that will stand up in the wind or with long straw. Yields have been increased. Oats have been created which ripen early and have stems that resist rust. Wheats, too, have been made to resist rust and to yield heavier crops. Corn (maize in Europe) may now have short or long stalks, and it may ripen earlier or later than usual, just as the farmer wishes, so as to meet market conditions. The yield of peanuts has been increased, and their resistance to leaf-spots heightened. As yet there is no control over the process of mutation. The breeder brings mutations about, then selects those for

cultivation that have desirable attributes. Some geneticists predict that ultimately it will be possible to create new varieties of plants and animals to order.

So far more work of practical value has been done in radiation genetics with plants than with animals, but there is no doubt that mutants can also be created in animals. Most of the work so far has been done with insects which breed rapidly. It was Professor H. J. Muller of Indiana University who opened up this field years ago with his experiments on fruit flies.

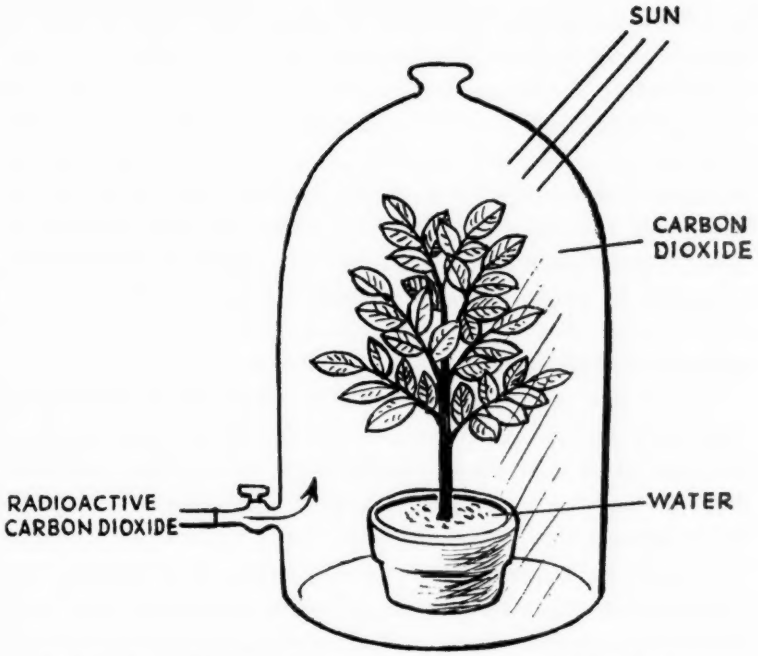
Isotopes as Tracers

Radioisotopes have illuminated much that was obscure in our understanding of life processes. Because it gives off telltale rays, many an isotope serves as a tracer. Hydrogen, for example, comes in three forms. One of them, hydrogen-3, or tritium, is radioactive. Combine it with oxygen to form water, and the plant cannot distinguish it from the hydrogen in ordinary water. Hydrogen-3 can be traced by its rays throughout a plant or an animal, so that it is possible to determine what becomes of nutriment as it is transformed into tissue.

By using radioisotopes in this way as tracers, scientists have at last succeeded in measuring the amount of nutrient taken by a plant from the soil and the amount taken from a fertilizer. Now it is known how a particular fertilizer should be used in cultivating a particular crop and the best time for incorporating the fertilizer in the soil. There is reason to believe that millions of pounds of phosphate could be saved by tobacco growers if they were to apply such knowledge. This holds good for all crops and all fertilizers. The discovery is important because of the heavy demand for fertilizers.

Leaves — and Food

Long-standing misconceptions of the physiological process that occurs in a plant have been corrected. For centuries it was thought



By following radioactive carbon dioxide after it is absorbed by the plant, scientists hope to discover the secret of photosynthesis.

that leaves and roots had different functions—that there were two unconnected and opposite streams of substance, one of which ascended from the soil and the other descended from the leaves. With the aid of radioisotopes, used as tracers, it has been discovered that leaves are also important means of feeding plants. Fertilizer (nitrogen), phosphorus and rubidium applied to leaves are absorbed and transported to other parts of a plant. A revolution in fertilization of soil is in sight.

Perhaps the most remarkable discovery of all is the way in which a plant is able to make sugars, starches and fats out of nothing but sunlight, the carbon dioxide in the air and water in the ground. The process is called photosynthesis. Until recently

it was one of the great mysteries of science. Much has still to be learned about it, but the major steps have been discovered with radioisotopic techniques. No practical use can as yet be made of this new knowledge, but it is possible that at some remote day starches, sugars, fats and amino acids (out of which proteins are built) will be synthesized in factories. Such foods would not be perishable. Optimists even predict that the problem presented by a world population that is growing more rapidly than the means of feeding it may be solved by commercial photosynthesis.

Microbes — and Tumors

What has been said about the improvement of plants by studying their physiological processes applies with equal force to animals. How does a cow produce milk or a sheep wool? How does the body of a carnivorous animal, man included, convert a piece of meat into tissue? How does a red blood cell gorge itself with iron? Such questions can now be answered with tracer techniques. Does digitalis go straight to the heart and stay there? Physiologists used to think so. But when digitalis was made radioactive with an isotope of carbon it was found that more of it goes to muscles that have nothing to do with the heart than to the heart itself. Similarly, radioisotopes make it possible to follow the course of a microbe or a virus through the body.

Some of the radioisotopes are remarkably selective. Radio calcium tends to concentrate in the bones, phosphorus in rapidly growing cells, iron in red blood cells, iodine in the thyroid gland. This selectivity has made it possible to devise new methods of diagnosis and treatments in medicine. Sometimes the radioactive isotope is incorporated by the chemist in a particular molecule. When this is impossible, indirect methods must be adopted. Thus tracer insulin can be obtained only by raising animals on radioactive foods and extracting the radioproducts. The fats of drugs, vitamins and hormones are thus studied. Both radioactive iodine and radiophosphorus have been used in diagnosing and locating brain tumors.

Radiation treatment of tumors is nothing new. It is almost as old as the X-rays. But X-ray machines are large and expensive. When cobalt is irradiated in a reactor, cobalt-60, a radioactive isotope, is formed. The gamma radiation from cobalt-60 will do the work of a powerful X-ray machine or expensive radium. Hence cobalt-60 is widely used in destroying malignant tumors.

The radioisotopes are not cure-alls, but they do prolong life. Outstanding examples are the use of radioactive iodine in treating too active thyroid glands or in alleviating angina pectoris and congestive heart failure. Radioactive phosphorus is used in the treatment of polycythemia vera, a disease in which there is an excessive production of red blood cells.

Factories are utilizing radioactive isotopes to determine the quality of rubber, steel or grease. To compare the cleansing properties of two soaps it is enough to spot pieces of cloth with butter to which a radioactive isotope is added and then wash them. If one piece of cloth remains radioactive longer after washing than the other, the soap with which it was washed is the poorer of the two.

Bombarding Atoms

Before atomic bombs were invented, isotopes were made at great expense with the aid of cyclotrons—machines that bombard atoms with suitable projectiles. The bombardment changes the structure of the target-atoms—converts them into isotopes. But in the great atomic "furnaces," or reactors, of Chalk River, Canada, and Oak Ridge, Tennessee, isotopes are produced so inexpensively that they are now widely used for research. It is enough to place any element in a reactor for a sufficient length of time to convert it into one of its isotopes.

The atom disintegrator or accelerator known as the cyclotron has not outlived its usefulness as a producer of radioisotopes. Oak Ridge National Laboratory's large cyclotron has demonstrated that some radioisotopes can be produced in large quantities economically.

Discovery of Atomic Energy

As we have seen, uranium, radium and many isotopes radiate energy. It follows that there must be energy in atoms. But the true relation of atoms and energy was not understood until Albert Einstein announced his "special theory" of relativity in 1905.

Einstein's Theory

Einstein presented a simple algebraic equation which states that mass is nothing but highly concentrated energy, and that mass can be converted into energy and energy into mass. The Einstein equation is part and parcel of every nuclear physicist's intellectual equipment.

As soon as the equation was published, physicists began to calculate how much energy was packed in a drop of water or a thimbleful of dirt. The amount was staggering. If a gram of matter could be annihilated, the energy released would be the equivalent of that obtained by burning 20 million tons of coal. By "annihilation" is meant the complete transformation of mass into energy, a transformation possible only in the sun and stars. On earth the best that scientists can do is to change a minute amount of the mass of one form of uranium into energy. What that minute amount can accomplish was frighteningly demonstrated by the first bombs dropped on the cities of Hiroshima and Nagasaki.

How energy in an atom could be released was for long a prob-

lem—an insoluble problem it seemed. The nucleus of an atom had to be broken up because virtually all the mass of an atom is concentrated there. But the nucleus appeared to be impregnable. Either it repelled the projectile that struck it, or it captured the projectile and thus converted itself into something else. An infinitesimal amount of energy was sometimes released by chipping the nucleus, as it were, but far more energy was expended in the chipping than ever came out.

Transformation of Matter

When the neutron was discovered in 1932 by Sir James Chadwick of Cambridge University a way was found to break down the nucleus. Since it is neither attracted nor repelled by anything, a neutron can slip in and break up the nucleus of a uranium atom, or it can be captured. In either case there is a transformation of matter.

Neutrons cannot be made to order. They dart about freely in space, or they are knocked out of matter. When beryllium is bombarded by alpha particles (helium nuclei), which are shot forth spontaneously by radium, it emits neutrons, and these can be used in an attack on other nuclei. Late in 1939 Drs. Otto Hahn and Fritz Strassmann of Göttingen, Germany, subjected uranium to neutron bombardment. One-thirtieth of a volt released 200 million volts. With that success begins the history of atomic power.

Splitting the Atom

Drs. Hahn and Strassmann observed that their uranium had been split in two by bombardment with neutrons. The two fragments were no longer uranium but two different elements—krypton and barium. When the masses of the fragments were added, the total came to a little less than the mass of the original uranium. Where was the rest?

Dr. Lise Meitner of Hahn's laboratory found the answer in

Einstein's algebraic equation. The little mass that was unaccounted for had been transformed into energy. At the same time Dr. Meitner applied the term "fission" to the splitting of the uranium atom—a term long used by biologists to describe the way that cells multiply by dividing again and again. A material that can be split with the release of energy is said to be "fissile."

Fission and Fusion

The only fissile material that occurs naturally is uranium-235, which is the reason for separating it from 238, with which it is always mixed in nature. All the natural uranium in the world consists of 99.3 percent uranium-238 and 0.7 percent uranium-235.

It is possible to create fissile material. Thorium, for example, can be transmuted into a form of uranium designated by the mass number 233. This is fissile, but it does not occur in the rocks. Plutonium is another fissile material not found in nature.

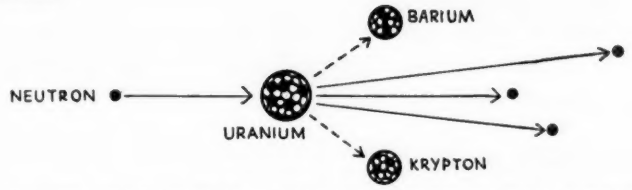
Fission is only one way of releasing the energy locked in an atom. Another way is "fusion," that is, the welding of two atoms. The welding is very different from ordinary welding. Weld two pieces of metal together, and we have a bigger piece of the same metal. Fuse two identical atoms together, and we have a different kind of matter and a tremendous amount of energy. In fusion, a process that so far has succeeded only with hydrogen, helium is created, the next lightest element. Hydrogen is the most abundant element in the universe. The stars are largely composed of hydrogen. All the helium in the universe must have been formed by fusing hydrogen atoms in stars.

The Fusion, or H, Bomb

This fusion of hydrogen atoms has been a theoretical possibility for at least 30 years. Hence the fusion bomb was in the minds of physicists from the time that they began to think of atomic bombs. It was technically easier to develop a fission bomb, and therefore it received primary consideration.

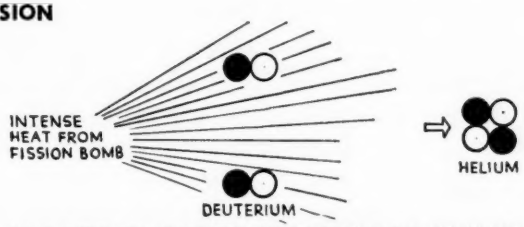
FISSION AND FUSION

FISSION



SPEEDING NEUTRON SPLITS URANIUM ATOM INTO FRAGMENTS SUCH AS BARIUM AND KRYPTON. THEY WEIGH LESS THAN URANIUM: LOST WEIGHT IS RELEASED AS ENERGY

FUSION



HEAT FUSES TWO DEUTERIUM ATOMS INTO HELIUM. HELIUM ATOM WEIGHS LESS THAN TWO DEUTERIUM ATOMS: LOST WEIGHT IS RELEASED AS ENERGY.

After Hiroshima and Nagasaki a few outstanding physicists had reached the conclusion that the fission bomb was frightful enough. Development of the fusion, or H, bomb lagged. When the news came in 1953 that the Soviet Union had exploded a fusion, or H, bomb the Truman Administration was spurred into action. The White House decided to proceed at once with the fusion bomb, even though there was some reason to doubt that a theoretical possibility could become a reality. Doubt gave way when prototypes of the hydrogen bomb were tested.

The hydrogen that plays its part in the H-bomb is not ordinary hydrogen. That is too sluggish. To make the bomb, deuterium (double-weight hydrogen) and tritium (triple-weight hydrogen) are used. When uranium-235 is split, about one-tenth of 1 percent of its mass is converted into energy; but when two atoms of the right kind of hydrogen are fused to form helium, the amount

of energy produced is about three-tenths of 1 percent of the mass. These fractional differences seem insignificant, but they account for the enormous superiority of the fusion over the fission bomb. The fission bomb that destroyed Hiroshima had the explosive power of 20,000 tons of TNT, but a hydrogen bomb can have the explosive power of 1 million tons of TNT.

An Unlimited Bomb

There are other reasons why the fusion, or hydrogen, bomb overshadows the fission bomb as a destroyer. The fissile material with which a fission bomb is loaded must have a "critical mass," which lies between 2.2 and 220 pounds. (The exact figure is a military secret.) Such a mass explodes spontaneously; therefore, it is divided and the two halves are shot together. An explosion occurs instantaneously. Hence the size of a fission bomb is limited by the critical mass.

There is no such limitation to the size of a hydrogen bomb. At the same time, it would not pay in terms of destruction to make a fusion bomb which has the explosive power of 50 megatons (50 million tons) of TNT. Much of that explosive power energy would be expended upward, that is, in blowing a momentary hole in the atmosphere.

The fusion of two atoms of hydrogen is effected violently. Heat measured in millions of degrees, heat as intense as that which causes the sun to glow, is necessary. But how is the necessary heat to be generated? When the uranium bomb was devised, the answer was obvious: Encase a uranium bomb in a hydrogen bomb; detonate the uranium bomb, and the necessary heat will be available to fuse hydrogen in 1.2 millionths of a second. In the present state of nuclear technology there is no other way of fusing hydrogen atoms in an H-bomb.

Atom: Instrument of War

THE NEWS OF THE ACHIEVEMENT OF Hahn and Strassmann was verified at Columbia University in 1939. The military significance was obvious to every physicist. Nazi Germany attempted to make a bomb, but it never engaged in experimentation on a scale large enough because it could not spare the scientists needed, because it did not have the necessary industrial resources, and because it had staked everything on the V-2 rocket.

For that matter, it did not prove easy to prod the United States government into action. Not until pacifist Albert Einstein in 1939 called the attention of President Franklin D. Roosevelt to the military implications of what Hahn and Strassmann had done was work begun here on the atomic bomb. That work was done by scores of the most distinguished physicists and engineers ever organized for research. After over $2 billion had been spent, largely on the great plants of Oak Ridge, Tennessee, and Hanford, Washington, the first atomic bombs were produced. In 1945 Hiroshima and Nagasaki were virtually blown off the map, and Japan was forced to sue for peace.

There is no doubt that war or no war, the discovery of Hahn and Strassmann would have been applied, but there is also no doubt that the exigencies of war accelerated the application by as much as 20 years. In the history of technology there is nothing that matches the development of the first A-bomb for daring. Usually scientists proceed slowly from laboratory to pilot plant,

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from pilot plant to full-scale plant. But in the case of the A-bomb the usual intermediate steps were omitted. To be sure, it was necessary to find out how the chain reaction could be controlled. After that was done in the Argonne Laboratory of the University of Chicago, full-scale atomic plants were built.

The Atomic Energy Act

Possessed of the most frightful weapon ever invented for large-scale death and destruction, the United States was faced with social responsibilities and moral duties of a new kind. But the military advantages conferred by the atom bomb could not be ignored in a world which was on the verge of war and in which the two social ideologies of capitalism and communism, of totalitarianism and democracy, were struggling for supremacy. Although scientists had declared that in a few years—the estimates varied from two to ten—other nations would develop atomic weapons, the United States decided from the outset to safeguard the monopoly of knowledge and skill that it had acquired. In 1946, only a year after the fall of Japan, came the Atomic Energy Act.

While it was recognized that the sudden release of atomic energy could do immense good for mankind, military thinking dominated the minds of the legislators who framed the act. The government was given despotic control of all fissile material. It was made the only purchaser of that material. It fixed the price of the material, and a generous price it was. It controlled research in atomic physics, and it suppressed applications for patents that disclosed methods for the more effective extraction of fissile material from ores and for the better exploitation of atomic energy of possible military importance. The Atomic Energy Commission was created in accordance with the act to develop the uses to which atomic energy could be put; for the framers of the act recognized the government's obligation to apply atomic energy in industry, agriculture, biology and medicine. Atomic research,

no matter for what purpose it was conducted, was controlled by the commission. Contracts were made with universities, industrial firms and institutions to carry out research for the government.

There can be no doubt that immense progress was made under this system. But there is also no doubt that it gave little opportunity for the private industrial development of atomic power. Radioisotopes were widely distributed by the Atomic Energy Commission at cost and less than cost to scientists who were engaged in medical, biological and agricultural research, and the results of the research thus conducted were freely published for the benefit of the world—all in compliance with the provisions of the act.

Atomic Energy Act of 1954

Much of this control over supplies of radioactive ore and the uses to which they could be put, and much of the secrecy in which the Atomic Energy Commission had, of necessity, to wrap the progress that was made, proved to be futile. Although the commission had built experimental reactors which might be used for research and the development of power, advance in the large-scale industrial uses of atomic energy was slow. In fact the United States lagged behind Britain. Then the White House announced that the Soviet Union had developed an atomic bomb. With the collapse of our monopoly of knowledge came the determination to pursue a more active policy in encouraging the building of atomic power plants by private companies and to foster the peacetime uses of atomic energy. To give private enterprise the rights and privileges it had long demanded it was necessary to liberalize the Atomic Energy Act of 1946. This was done in 1954.

Despite this liberalization, the act of 1954, like that of 1946, is dominated by military thinking. Every advance in the utilization of atomic energy is "born" to be "classified," that is, to be kept secret no matter to what purpose it may be put. The Atomic

Energy Commission releases for general use only information which has no military application. Thus on the whole the act of 1954 still places military security above peaceful uses of atomic energy.

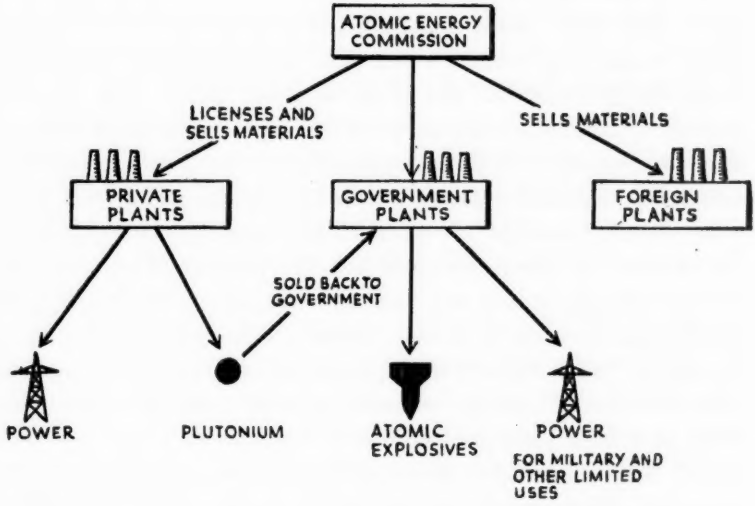
Dixon-Yates Controversy

The act of 1954 could only partially carry out President Eisenhower's recommendations to Congress, which proposed closer cooperation with our allies, wider and more efficient dissemination of information about atomic energy, and broader participation in the development of peacetime uses of atomic energy. One reason why the amendments of the act of 1946 assumed the form they did in 1954 was the controversy aroused by what came to be known as the Dixon-Yates contract. The Atomic Energy Commission was willing to accept this contract, which would have left in the hands of a group of southern utilities the production and distribution of the additional electric power needed in developing a great project that the commission had started at Paducah, Kentucky.

Until that time the Tennessee Valley Authority (TVA) had supplied power in the Memphis area to the various plants of the Atomic Energy Commission, but it could not meet new demands without building new plants. The Eisenhower Administration, committed to the private development of electric power, sidetracked TVA. The storm of opposition in Congress against the Dixon-Yates contract, however, could not be weathered. The bill then before Congress was destined to become the Atomic Energy Act of 1954. It had to be amended to satisfy the opposition, and with its amending the liberalization originally contemplated was lost.

The act of 1954 still gives the Atomic Energy Commission monopolistic ownership of all mined fissile material. But licenses may be granted to industrial firms which want to make use of fusionable or fusible material, provided the commission thinks

ATOMIC ENERGY ACT OF 1954



well of their plans. The licenses do not strip the commission of its title to the materials that have passed into private hands. When atomic energy is released in a reactor, the production of plutonium as a by-product is inevitable. Because plutonium is a good atomic explosive all the plutonium that may be produced by a power company becomes the property of the commission at a fair price.

Private Power Plants

This provision for the granting of licenses has done much to permit private companies to plan the construction of power plants. The Atomic Energy Commission may not go into the power business directly under the act, but it can sell the power generated in plants of its own that serve a purely military purpose. With congressional approval it may also sell the power it produces in experimental or demonstration plants. These are limitations on the sale of this government-generated power. Cooperatives, gov-

ernment agencies, and regions where there is a lack of power are to receive preferential treatment.

The public utility companies have pointed out over and over again that they cannot make a reasonable profit out of atomic power unless they receive a fair price for by-product plutonium from the government. But what is a fair price? The Atomic Energy Commission fixes the price. When it comes to plutonium the commission is in direct competition with power companies which buy fissionable materials from it. The charge for the fissionable materials will be low so as to encourage private enterprise to go into the power business, but the price paid by the commission for plutonium will have to be high enough to make the production and sale of atomic power (in the form of electricity) profitable. We have here a disguised subsidy, for the commission may have to sell reactor materials at a very low price and buy back at a high price the plutonium transmitted from these materials. It is conceivable that a time may come when the government will have enough plutonium for bombs. Will a high price still be paid for plutonium?

The act of 1954 allows an inventor to patent an improved method of utilizing atomic energy, but he must grant a license to the commission and others if called upon to do so. So we have compulsory licensing, a principle that violates the spirit of the patent law as it has been developed in the United States. A compulsory license will not be easily granted, but the underlying principle written in the act of 1954 is bound to plague inventors.

Under the act of 1954 the President may give limited information on our own developments in atomic physics and engineering, even in military matters, to some allies and friends. The Atomic Energy Commission may give or sell materials for power production as well as equipment. These liberal provisions made it possible for the United States to enter into agreements with about 30 nations for the exchange of atomic information. It also made possible the International Conference on the Peaceful Uses of Atomic Energy held at Geneva in August 1955.

Atom: Deterrent or Destroyer?

In the past decade military thinking has been profoundly influenced by the role of the atomic scientists. Since World War II the United States has acquired bases in Europe from which atomic attacks can be launched. Whether or not atomic weapons will do away with ground forces is still a debatable question. If atomic weapons are used in another world war, retaliation is inevitable—and retaliation with atomic bombs means nothing less than the destruction of whole nations, perhaps of all civilization.

The possibility of mankind's self-destruction was never more eloquently and fearfully stated than by Sir Winston Churchill in these words:

"Death stands at attention, obedient, expectant, ready to serve, ready to sheer away the peoples *en masse;* ready if called on to pulverize, without hope of repair, what is left of civilization. He awaits only the word of command. He awaits it from a frail, bewildered being, long his victim, now—for one occasion only—his Master."

H-Bomb Devastation

Informed estimates of the devastation that can be wrought by a hydrogen bomb bear out Sir Winston. What is now regarded as the crude A-bomb of 1945 devastated an area one mile in radius. Today we must think of hydrogen bombs which can devastate an area of at least ten miles in radius, with heat effects that would be felt much farther out. It has been estimated, for example, that Chicago and all its suburbs would be wiped out by the blast and flash of a hydrogen bomb with 1,000 times the energy of the Hiroshima type. The reason is that the radius of heat dissemination increases more rapidly than that of blast.

In the tests of March 1954 the atoll of Elugelab, a half-mile long and a quarter of a mile wide, was blown away. In the water-filled crater that was left, one mile in diameter and 175 feet deep, a 17-story building could have been immersed. Beyond the crater was an area of devastation six miles in diameter. Seven miles

farther out there was heavy damage, and noticeable effects could be detected at a distance of ten miles.

One such bomb could destroy any city of half a million; two or three could destroy any metropolis. Thirty hydrogen bombs could blast a corridor across Europe 20 miles wide from the Baltic Sea to Switzerland. A one-megaton hydrogen bomb would kill 17,000 men a hundred yards apart. Corresponding figures for a five-megaton and ten-megaton bomb would be 39,000 and 50,000 men. The side that won in the air would win the war. Hence the emphasis placed on air power by the United States and the Soviet Union.

Change in Military Technique

In 1945 the only atomic weapons devised up to that time were bombs. These were to be strategically used, that is, exploded on a city like Chicago, which is a junction of 21 railroads, or on New York or any other port that serves as a national gateway for the entrance and exit of goods and troops, or on cities like Pittsburgh, St. Louis or Cleveland, which are not only industrially important but also supply industry in general with machines and essential materials. That atomic explosives could be used tactically—that is, on the battlefield—was not considered possible ten years ago.

Military opinion rapidly changed as weapons were developed for combat use. Today there are guns which can be hauled by tractors and can fire atomic shells. Indeed, a whole group of atomic weapons has been developed. In addition, there are guided missiles which have a transoceanic range. These missiles are the equivalent of long-range artillery—not airplanes. In their latest form they are to be provided with thermonuclear warheads, that is, warheads which are hydrogen bombs. They are intended to be used strategically, that is, against such wide-spreading targets as London or New York, just as the V-2 rockets were used in World War II against London. Some of these guided missiles would be launched from planes, some from submarines. It is possible that

in ten years guided missiles will be developed of which a single one can reduce to rubble an industrial area of 200 square miles. One of these missiles, the 5000-mile ICBM (Intercontinental Ballistic Missile), should be able to soar across the Pacific Ocean in less than half an hour.

Will Atomic Weapons Prevent War?

The new atomic weapons, whether designed for strategic or tactical use, have changed the whole character of war. But will they prevent war because they are so terribly destructive? They may act as deterrents but not as preventives. The experience of history argues against the theory that as weapons become more terrible, war becomes less likely. The Maxim gun was first used by the British colonial forces in the Matabele war of 1893. Four guns killed 3,000 warriors out of 5,000 who charged five times in an hour and a half. The gun was again effectively used in 1895 in the Chitral campaign on the Afghan frontier against the fanatical mountaineers of the Hindu Kush. The battle of Omdurman in 1898 was the classical example of the Maxim's deadliness. At the command of the British general, Kitchener, no fewer than 20,000 Sudanese dervishes were slaughtered. A horrified House of Commons discussed the possibility of an international agreement to outlaw the weapon. Yet the machine gun became a part of an army's indispensable equipment. If gas was not used in World War II this was largely because high explosives were more destructive. There is no evidence to support the theory that leaders will not dare to use atomic weapons in a future war because their own country—and even civilization itself— might be destroyed. We must always reckon with dictators of the Hitler type.

War Without Victors

In bygone days war was horrible enough. Today it grows more and more horrible as nuclear weapons are improved. If there is a defense against these weapons—as yet none has appeared—there is still no way of preventing war and escaping its consequences.

It cannot be emphasized too often that there will be no victor of a world war waged with atomic bombs. The possibility must be considered of destroying a culture that it has taken millennia to build—even the continued existence of plant, animal and human life—if the atmosphere is deliberately poisoned with long-lived radioactive isotopes.

This is why it is essential that some international agreement be reached for the absolute control of the use of atomic energy for war purposes and why the statesmen of the great powers have met time and time again since 1945 in what have so far been vain efforts to save mankind from self-destruction and at the same time permit the utilization of the richest source of energy known to us for peacetime ends.

It may well be that the needs of peace may enable the great powers to reach an agreement outlawing the use of atomic energy in war. Great sums of money and exceptional scientific ability are required to exploit atomic energy to the utmost for peaceful purposes. Large-scale nuclear research is therefore limited at present to the United States, Britain and the Soviet Union, although the contributions to atomic knowledge of France, the Netherlands, Germany and the Scandinavian countries are by no means negligible.

Geneva Atomic Conference

The conference on atoms for peace held at Geneva in August 1955 had an effect on the panel of laymen who in February 1956 submitted to the Joint Committee on Atomic Energy of the 84th Congress a report which is one of the most important public documents published by the United States in recent years. If the Geneva conference taught anything it taught the utter futility of secrecy. For at Geneva it became clear that so far as the peaceful uses of atomic energy are concerned, there are no secrets.

After holding 15 seminar or discussion groups, preparing approximately 50 special studies, and consulting some 327 authori-

ties, the panel of laymen reached the conclusion that the policy of secrecy hitherto pursued in accordance with the Atomic Energy Act of 1946 and 1954 was not only futile but positively harmful in retarding the introduction of atomically produced power and the fulfillment of President Eisenhower's plan for the development of regions of the world which lack fuel. Accordingly, the panel recommended that reactor technology be opened to anyone and that a free market for uranium and other necessary atomic "fuels" be created. The scientists have been criticizing our government's atomic secrecy for years, chiefly because the policy pursued by the United States—the consequence of purely military thinking—was absurd in view of all that was known about atomic physics abroad. The laymen's panel reinforced the scientists' argument by dwelling on the social and economic consequences of trying to keep secrets that were no longer secret.

Should the Bomb Be Barred?

Because of the destructiveness of A- and H-bombs, it is now impossible to achieve a diplomatic objective by calling on a powerful army to enforce a policy if necessary, for war means annihilation. This explains Britain's policy of emphasizing the possibility of coexistence between Communist and non-Communist states. The British go so far as to maintain that the invention of the fusion, or hydrogen, bomb has made the Suez Canal obsolete and that the British Commonwealth lost nothing by relinquishing the canal to Egypt. Sir Winston Churchill told the House of Commons on July 12, 1954 that his last visit to the United States was prompted by reports from Bikini about the test explosion of a fusion bomb on March 4, 1954. Not long after that date he made known his conversion to the idea of "peaceful coexistence" with Communist nations.

The British still base their policy on the theory that the atomic bomb, whether of the fission or fusion type, is a deterrent of war and that more atomic bombs are available in the West than in the U.S.S.R. The complacency that the United States felt when it believed it had a monopoly of manufacturing atomic bombs was dispelled in 1949 by the announcement that Moscow had tested its first fission bomb. This news immediately affected Washington's military as well as political policy.

Danger of Fall-out

The fear that civilization may be destroyed or that, at best, mankind will lapse into barbarism if a war is fought with atomic

weapons is based not only on the terrific heat and blast and the burns and radiation sickness that follow the explosion of an atomic bomb of any type, but on the more persistent menace of "fall-out," that is, the slow settling of radioactive dust and particles carried for miles by the winds after an explosion.

The danger that attends fall-out was driven home after the test explosion of a hydrogen bomb at Bikini on March 4, 1954. On that occasion fall-out affected the *Lucky Dragon,* a Japanese fishing vessel supposed to be well out of the danger zone. A crew of 23 were afflicted with radiation sickness, and one died from causes on which Japanese and American physicians do not agree. After having exhaustively studied this accident the United States Atomic Energy Commission candidly reported on February 15, 1955 that "about 7,000 square miles of territory was so contaminated that survival might have depended on prompt evacuation of the area or upon taking shelter and other protective measures."

Up to the present, fall-out has been regretted as an unfortunate but unintentional accompaniment of an atomic explosion. But fall-out can be intentional. This being so, fall-out may even prove more frightful than it has been depicted by the Atomic Energy Commission. Professor Leo Szilard of the University of Chicago has pointed out that a ruthless belligerent might use a radioactive cobalt bomb against an enemy for the purpose of wreaking death over a period of years. According to him, it would take only 400 one-ton hydrogen-cobalt bombs to wipe out all life. The more skeptical physicists doubt that a cobalt bomb will ever be made. In an explosion most of the cobalt would be vaporized. Moreover, the atmosphere is vast. But it must be admitted that other radioisotopes besides cobalt-60 could be incorporated into a hydrogen bomb, and these could contaminate everything for centuries and make life on earth impossible.

The Bomb and Genetics

The danger from fall-out is in large part a genetic or hereditary danger. Gamma rays are given off by radioactive fall-out, and

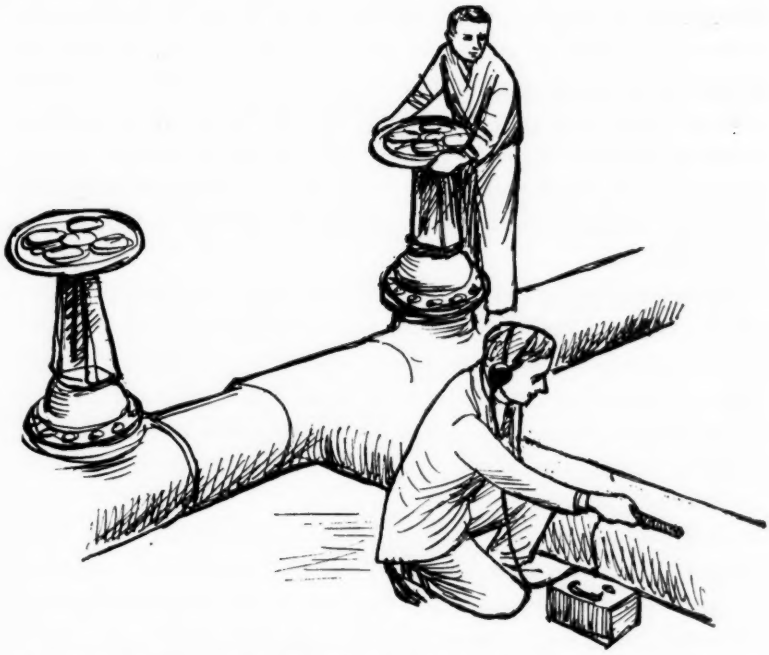
gamma rays are much more powerful than X-rays, which they resemble. As we have seen in the discussion of heredity, exposure to gamma rays or X-rays may result in mutations, that is, permanent departures from the parental stock. The departures breed true generation after generation. They are usually slight yet significant. The Atomic Energy Commission is well aware of them but sees no cause for alarm. It holds that "the average amount of radiation exposure received by residents of the United States from all nuclear detonations to date (February 15, 1955) has been about the same as the medical exposure received from one chest X-ray." Hence it concludes that there is "no basis for serious concern at the present time."

Geneticists agree with this view. They are concerned, however, not with what may happen in our time but with what will happen in the future if atomic bombs are tested year after year and highly radioactive particles are blown about.

Fruit Flies and Mice

What the geneticists fear is an eventual deterioration of the human stock, a loss of vigor, a reduction in health, an increase in hereditary disease. A carrier of a hidden hereditary defect may marry and transmit it to generation after generation. Dr. H. J. Muller, a leading geneticist, believes that "even an atomic explosion like that of Hiroshima probably results in the death of more people of future generations, all told, than those killed now and in the handicapping of many more."

According to the calculations of Dr. Alfred H. Sturtevant of the California Institute of Technology, 1,800 of the 90 million children born in 1954 were genetically affected by the fall-out of the test H-bomb explosions, a mathematically negligible number considering that there are over 2,000 million people in the world. But human life is never negligible, and that is why the geneticists continue to harp on the biological hazard. Dr. Sturtevant arrived at his estimate before the outcome of experiments with mice were known. On the basis of these experiments the Atomic Energy



When oil stock is changed in the pipeline, radio isotopes may be injected in the new stock. A Geiger counter will indicate the arrival of the new stock, and the valve is turned to switch the new stock into a new tank.

Commission states that "the mutation rate in the mouse is ten times as great as that observed in fruit flies." Dr. Sturtevant has therefore underestimated the hazard of fall-out.

Should Nuclear Tests Stop?

Because of its terrible power, because of possible genetic consequences, the Russians have proposed that there shall be no more tests of thermonuclear, or hydrogen, bombs. There is a considerable body of opinion in this country, in Europe, and particularly in India, which endorses the Russian proposal. But diplomacy must face realities. In this case the reality is the Russian record, a record that inspires no confidence. The United

States regards Russia's proposed ban as a device to impress the Communist bloc in Asia and Europe. All nations engage in propaganda, the United States included. In the atmosphere of distrust that is created by propaganda the hope of reconciling Russian and American doctrine is dim. So far as present indications go, the "cold war" may continue for years, although its character changed after the Big Four conference in Geneva of July 1955.

If the banning of tests were feasible it might slow down further development of hydrogen bombs and accelerate the improvement of defenses. Stockpiling would still go on, and so would the improvement of hydrogen bombs on paper. But what nation would be in favor of accumulating hydrogen bombs which would be old-fashioned compared with those that might be theoretically developed?

The prohibition of tests would not necessarily stave off a war waged either with fission bombs or with conventional weapons. It is true that violations of the test-ban would be easily detected. The first Soviet fusion bomb was tested in 1953, only nine months after our first droppable bomb of the same type. Dr. Vannevar Bush has testified that not only did we detect this first Soviet test but that we were able to determine what kind of a bomb had been tested and to infer some of its characteristics.

We considered and rejected the prohibition of fusion-bomb tests even before we had our first crude fission bomb. Even if prohibition were accepted by all the world's great powers it would probably be ineffective to prevent atomic warfare at this late date. Military nations have never been content with their means of destruction. Out of the old *Monitor* came the superdreadnought, and the superdreadnought in turn gave way to the airplane carrier. The invention of gunpowder was followed by the introduction of high explosives, which seemed frightful enough until the atomic bomb was developed. A few physicists, among them Robert Bacher, opposed the development of the fusion bomb, arguing that a point had been reached where higher

destructive effects than those produced by the fission bomb were futile. J. Robert Oppenheimer opposed the hydrogen bomb on moral grounds.

So long as there is an armament race, so long will there be tests of nuclear weapons. If the world ever agrees to disarm it will of necessity have to abandon atomic bombs, and with that abandonment the need of more tests would disappear. Meanwhile, the temptation to improve nuclear weapons of all types is apparently irresistible.

Both the United States and the U.S.S.R. would like to abolish atomic weapons. Neither has abandoned its efforts to achieve that end. There is a mutual willingness to exchange proposals and to attend international meetings, like the Big Four "summit" meeting of 1955. The proposal made by Thomas E. Murray of the Atomic Energy Commission for an international exhibition of atomic weapons which would force the great powers to outlaw atomic warfare would, however, probably be regarded by the Russians as a threat.

Accidents — and Bombs

Neither the United States nor the U.S.S.R. can hope to win a war waged with atomic weapons. Although this is generally recognized, an atomic war might be the outcome of a mistake or a reckless decision by a minor military personage, without sanction of the highest authority. Apart from this probability it is hard to conceive of a war deliberately started with hydrogen bombs. The United States has more to lose in such a war than the U.S.S.R., for it has more targets in the form of important industrial centers and large cities. Hence the ceaseless efforts of both great powers to maintain advantages which in a few years may prove fanciful.

There is reason to believe that the United States has a superiority in atomic tactical weapons, which would be used on the battlefield. The U.S.S.R. has the biggest military force in the world, a force armed largely with conventional weapons, so far

as we know. Russia's numerical superiority must therefore be offset by the West with atomic weapons. The indications are that the atomic armament race will go on, although its character will change as Russia more nearly matches the United States in nuclear power.

What mankind needs above all is a sense of security. Is a standing army a threat to security? Must the world disarm for that reason alone? Opinion on these questions has changed. Even the Russians admit that because a nation has a large standing army it does not follow that war is inevitable. When wars break out it is because nations push each other into war through political maneuvering which creates intolerable tensions that may precipitate a quick military move.

Surprise Attacks

It is true that wars have often begun with surprise attacks—witness Japan's attack on Russia at Port Arthur in 1904 and the bombing of Pearl Harbor in December 1941. But political tension always precedes the attack. It is often argued that possession of atomic bombs, whether of the fission or fusion type, tempts a possessor to make use of them in an overwhelming, massive surprise attack and thus win a war with a single, fatal blow. Recent efforts to prevent war have centered on the prevention of surprise attacks.

The suggestion that atomic bombs represent a safeguard against a treacherous violation of an agreement to disarm is absurd on its face. We can hope for no more than a ban on the use of atomic weapons, and this for the reason that nothing is known about the size of stockpiles and that atomic bombs and shells can easily be concealed. Treaties and "gentlemen's agreements" have been violated time and time again in the past. There is no reason to suppose that an agreement not to make nuclear weapons would prove any more sacred. International control of some kind is essential, but the problem of devising a formula of control which will be acceptable to all the great powers has not yet been solved.

Can the Bomb Be Curbed?

SCIENCE IS OFTEN CHARGED WITH INDIFFERENCE to the uses that are made of its discoveries. But the physicists who developed the atomic bomb, frightened at their own success, far from being indifferent, were the first to call attention to the dreadful consequences of a war waged with atomic weapons and suggested a system of internationally controlling the utilization of atomic energy both in war and in peace. For the reactor, or "furnace," in which fissile material is split is indispensable in producing both power for peaceful industries and an explosive material—plutonium—with which bombs are loaded. From the outset the scientists pointed out the possibility, even the certainty, that a country ostensibly engaged in utilizing its reactors for the production of power and other peaceful purposes might secretly be producing explosive materials.

Even before the first atomic bomb had been made and exploded, the scientists realized that a world war waged with uranium-235 or plutonium or, for that matter, with hydrogen could be suicidal. On the basis of information supplied by physicists and predictions of world-wide disaster if the uses to which atomic energy could be put were not controlled, Secretary of War Henry L. Stimson in 1945 appointed an Interim Committee to study this problem. The findings of the committee convinced the Secretary of War that international control of atomic energy was essential. The United States has never changed its mind on the need of inter-

national control, but it has had to abandon its more drastic proposals for exercising control, chiefly because of the opposition of the U.S.S.R.

The report of Secretary Stimson's Interim Committee was followed on August 6, 1945 by the first public statement on the atomic bomb, a statement in which President Truman made it clear that the United States would keep secret what it knew about making and using atomic bombs "pending further examination of possible methods of protecting us and the rest of the world from the danger of sudden destruction." There was also a promise of "further recommendations to the Congress as to how atomic power can become a powerful and forceful influence toward the maintenance of world peace."

The promised recommendations were transmitted to Congress on October 3, 1945. They emphasized the necessity for international control of some kind, "the renunciation of the use and development of the atomic bomb" and the direction of atomic energy "toward peaceful and humanitarian ends." The President therefore proposed the initiation of discussions "first with our associates in this discovery, Britain and Canada, and then with other nations." Out of the discussions came the Truman-Attlee-King declaration of November 15, 1945.

UN Atomic Energy Commission

In the main, the declaration followed President Truman's plan. The use of atomic energy in war or for destruction was to be forbidden, and its use for peaceful ends promoted. It was further proposed that a United Nations commission study the problem thus presented and devise ways of safeguarding the world by a system of inspection "to protect states against the hazards of violations and evasions." The United Nations commission was to "proceed by separate stages," so as to win the confidence of the world. We have here the essence of recommendations subsequently made in the Acheson-Lilienthal report and the Baruch proposals.

The Truman-Attlee-King declaration was accepted by the

U.S.S.R. at the December 1945 Moscow conference of the Big Three foreign ministers. The meeting agreed that a United Nations Atomic Energy Commission was to be created, to be composed of the 11 members of the Security Council. The recommendations of the Moscow meeting were unanimously adopted by the United Nations General Assembly, and the United Nations Atomic Energy Commission was established on January 25, 1946.

So far only general principles had been discussed. Some mechanism had to be invented for applying them when an emergency arose. The task of invention was left by Secretary James F. Byrnes to a committee which was appointed in January 1946 and which had Under Secretary of State Dean Acheson as its head. The committee was aided in its deliberations by a Board of Consultants, of which David E. Lilienthal was chairman. The findings of the two groups were incorporated in what came to be known as the "Acheson-Lilienthal Report," published on March 28, 1946, and submitted, not as a final plan, but "as a foundation on which to build."

Acheson-Lilienthal Report

The report accepted the principles of outlawry of the atomic bomb as a military weapon and of inspection. But these principles were not considered adequate. So it was suggested that they be supplemented by the international ownership and management of fissile material from the mine to the factory, power plant or laboratory by an Atomic Development Authority, under the United Nations. The Authority was to carry on atomic research of military importance, but the peaceful development of atomic energy was to proceed under licenses which it would grant.

But how was the world to make peaceful use of atomic energy when the United States alone knew how to use atomic energy in peace or war? The Acheson-Lilienthal report answered by providing for the release of information in stages. It frankly stated that if the plan failed or the international situation collapsed the United States would still be safer than any other nation because of its monopoly of unrevealed knowledge.

Baruch Proposals

Out of the Acheson-Lilienthal report came the proposals that Bernard M. Baruch presented to the United Nations Atomic Energy Commission on June 14, 1946. He broadened the recommendations of the report by a threat of "condign punishment" for evasion of international control. Under the United Nations Charter sanctions can be invoked only with the concurrence of the five permanent members of the Security Council—China, France, Britain, the United States and the Soviet Union. The Baruch proposals would have done away with the veto power that any one of the five could exercise in an hour of atomic peril. No veto was "to protect those who violate their solemn agreements not to develop or use atomic energy for destructive purposes."

The Baruch proposals were accepted in principle by all the members of the United Nations Atomic Energy Commission except the Soviet Union and Poland. By exercising its right to veto any proposal that came before the Security Council the Soviet Union had successfully thwarted the United Nations in performing some of its more important functions as defined in the Charter. The Soviet Union could do so again.

The United Nations Atomic Energy Commission issued three reports in efforts to reconcile the opposing views of the Soviet Union and the Western world, but it proved impossible to end the deadlock. The commission finally recommended the suspension of further argument. Nevertheless, the conception of inspection, international control and punishment for evading that control was not dead. At the Paris meeting of 1948 the General Assembly by a vote of 40 to 6 approved parts of the United Nations Atomic Energy Commission's first and second reports and called on the commission to continue its work, a suggestion that came to nothing.

Russia's Suggestions

It was manifest from the first that the Soviet Union had no intention of yielding one jot of its sovereignty to any international authority. On June 19, 1946, only five days after Mr. Baruch

appeared before the United Nations Atomic Energy Commission, the Soviet Union came forth with its first set of proposals, framed to preserve its sovereignty. The proposals insisted that the United States must agree to stop the production of atomic weapons, and destroy what atomic weapons it had, before international control was to be exercised. Mr. Baruch's proposed abridgement of the veto power of the Security Council was rejected. Thus a permanent member who had violated the international regulations could veto any measure taken to punish him.

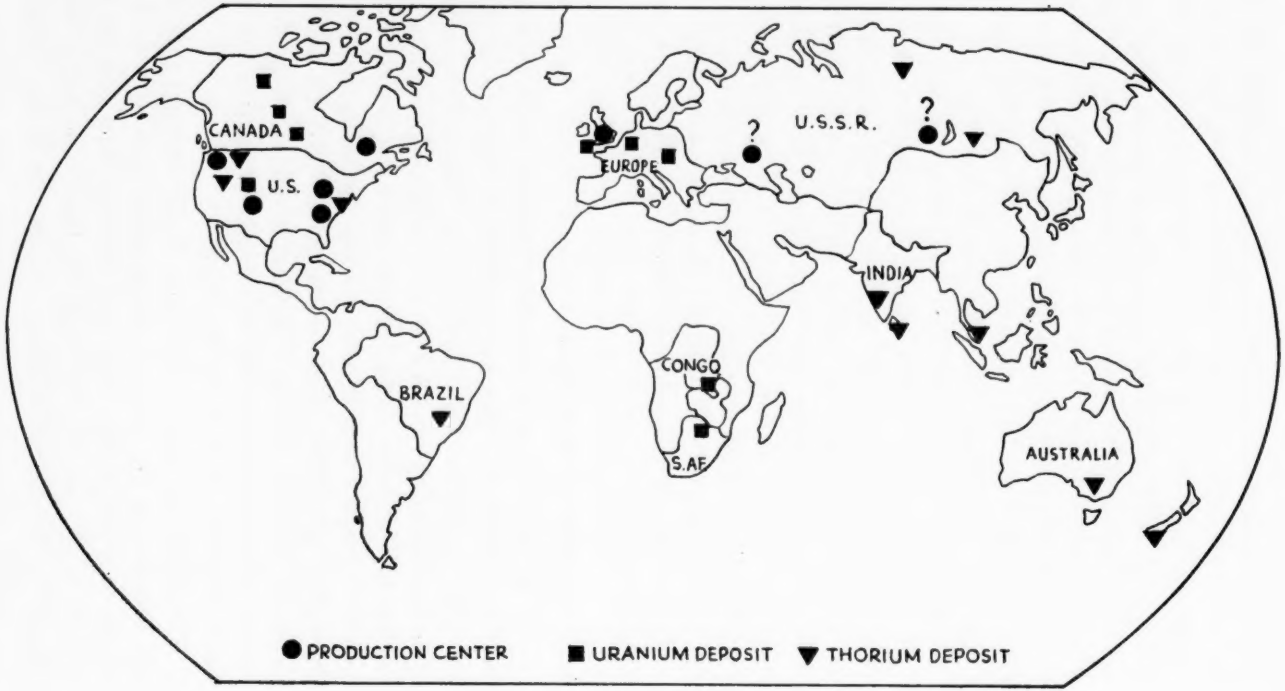
A year later, on June 14, 1947, the Soviet Union came forth with a new set of proposals, which dealt chiefly with controls. It now consented to periodic inspection of mines and plants by an international body, but only of *declared* plants, with special investigations permitted only when there were "grounds for suspicion" that regulations were being evaded. On September 25, 1948 the Soviet Union modified its position further by stipulating that conventions for outlawing the production and use of atomic weapons and for international control go into effect simultaneously.

New Approach to Atom Control

The announcement of President Truman on September 23, 1949 that the Soviet Union had exploded an atomic bomb changed the whole situation. What had been an American monopoly of technical knowledge and skill in the production of atomic bombs vanished. Thereafter efforts to control atomic energy followed new lines. Inspection of all atomic mines and plants, international ownership and management of dangerous facilities and source materials, national quotas of fissile material, sanctions to be enforced despite the veto power that might be exercised in the Security Council—all went by the board.

The desire for peace is so strong in all countries that despite the inability of the Western democracies, especially the United States, to arrive at any satisfactory understanding with the Soviet Union, it will not die. Although the Baruch proposals were endorsed by the United Nations (except the Soviet Union and

GEOGRAPHY OF ATOMIC POWER



Poland), it is not likely that they will ever be revived. The chief reason is the change in technology that has occurred since 1945.

In 1945 the United States had a monopoly of the knowledge and the skills required to make atomic bombs. It also had the only stockpile of bombs. Since then both the Soviet Union and Britain have been producing and testing bombs. Scientists and engineers of a dozen nations know as much about the production of atomic energy for military and peaceful purposes as the United States. What was once an American monopoly is broken, and because it is broken the terror of another world war is more acute than ever. Hence the persistence of the efforts to arrive at some international agreement for the abolition of atomic weapons and for general disarmament.

Because of the change in technology and the possession of atomic bombs by the Soviet Union the formulas laid down in the Acheson-Lilienthal report and the Baruch proposals are outmoded. President Eisenhower is the leader in a new approach. He places his hope of insuring world peace on cooperation rather than on stiff rules. If the statesmen of the great powers can be induced merely to sit down and talk world peace, something constructive is bound to emerge.

Geneva I: Aerial Inspection

The Eisenhower method was first tested at the summit conference held at Geneva in July 1955. Persuasively the President stated the case for general disarmament, which, in turn, would include the prohibition of atomic warfare. He even went so far as to propose the exchange of blueprints of military establishments and aerial photographs of fortifications, cities and anything else of military interest—a proposal unprecedented in history.

It was manifestly for the purpose of preventing a surprise attack that President Eisenhower declared his willingness to exchange military information, permit aerial reconnaissance of fortifications throughout the world, inspect industrial plants and monitor communication systems. In fact the plan included the essentials of the Baruch proposals and more, with voluntary cooperation

taking the place of an international police. With such a voluntary international system for the exchange of information a surprise attack would be impossible, and with surprise thus disposed of, the likelihood of making use of atomic bombs would disappear. Retaliation would be inevitable if a surprise attack were made. Attack and counterattack would be suicidal. Hence there would be no atomic war.

The President's plan is impressive. But the difficulty of carrying it into practice seems insurmountable. Waging war is a complicated business in the 20th century. Every civilian takes part in it directly or indirectly. There must be preparation. A sudden increase in Red Cross activities, a doubled and trebled output of steel, the rapid expansion of government offices to supervise production would arouse suspicion. Transportation and communication would demand supervision beyond the resources of any country.

Despite the difficulties presented, the President's plan is still being studied in Washington. It is hard to imagine the United States revealing the size of its stockpile of atomic bombs or throwing its defense system open for inspection by any power. The United States, as already pointed out, has more to lose by a surprise atomic attack than the Soviet Union. It is not likely that the Soviet Union will relinquish this advantage. Some loss of sovereignty is called for by the President's plan. Yet Premier Nikolai A. Bulganin in September 1955 declared his willingness to meet President Eisenhower part of the way. Bulganin was in favor of prohibiting the use of atomic weapons as the last step in a disarmament program—a reversal of earlier policy, since in the past the Soviet Union has always insisted on outlawing atomic bombs before it would discuss disarmament or any other way of easing international tension. Now the Soviet Union agrees with the United States that a surprise attack must be prevented. It remains for the world's statesmen to find a formula which will be acceptable not only to the United States and the Soviet Union but to all powers, small and great.

Geneva II: 'Atoms-for-Peace' Conference

The Eisenhower plan for achieving international cooperation merely by an exchange of views was applied again in a second conference, the International Conference on the Peaceful Uses of Atomic Energy, held in Geneva in August 1955. This "atoms-for-peace" conference, as it came to be called, grew out of a speech which President Eisenhower delivered on December 8, 1953 before the United Nations General Assembly and in which he invited the nations of the world at least to pool their knowledge of atomic energy for peaceful purposes and thereby help one another to ease the lot of mankind. Nations with stockpiles of fissionable material were to contribute some of it to less fortunate nations for scientific research. This proposed exchange of knowledge and these contributions of atomic material would not only put to work atomic power where it was needed but would advance the development of agriculture and medicine and industry. In this way, said the President, "the contributing powers would dedicate their strength to serve the needs rather than the fears of mankind."

The Eisenhower proposal did not mention any rules which nations would have to observe, nor any punishment for infringement of human rights, nor methods of control, nor inspections of mines, factories or institutions where fissionable material would be used, nor an accounting of fissionable material. Even the Soviet Union, ever ready to object to almost any proposal originating in the United States, could find no fault with the complete freedom of action that was to prevail under the Eisenhower "atoms-for-peace" plan.

As evidence of its faith in the President's plan the United States offered first 100 kilograms, then an additional 100 (440 pounds in all) of fissionable material to serve as "fuel" in experimental reactors to be erected in various countries. Britain followed by pledging 20 kilograms. India promised "considerable quantities" from its important deposits of thorium.

Seldom has a proposal calling for world cooperation been

received with the enthusiasm that greeted President Eisenhower's atoms-for-peace plea. The United Nations at once planned an International Atomic Energy Agency and made arrangements for the International Conference on the Peaceful Uses of Atomic Energy, which was held in Geneva August 8 to 20, 1955. This conference proved to be the most important scientific meeting in history.

Pooling Atomic Knowledge

Scientists of 73 nations came to Geneva not only as scientists but as official delegates of their countries. The plans formulated by the United Nations were carried out in both letter and spirit. There was the utmost frankness in revealing what each nation had accomplished. Only information of military importance was withheld. Even the Russians, regarded as particularly secretive, disclosed what they had been doing with atomic energy in the development of their country.

It turned out at Geneva that discoveries in the use of atomic energy for peacetime purposes which had been regarded as deadly secrets were not secrets at all. Britain, the U.S.S.R., France and other countries had been carrying on research independently along the same lines, arriving at similar conclusions but saying nothing about them until the Geneva conference. Thus the folly of atomic secrecy was unwittingly exposed. But nobody laughed. No Voltaire appeared to deride the policies that had been pursued by all the great powers since 1945.

The Geneva conference achieved its purpose. Politics and bombs were not mentioned. No recommendations were made; no resolutions were passed. Knowledge was exchanged in the traditional spirit of science. The world's scientists departed from Geneva convinced that they had participated in a momentous gathering. World attention turned increasingly to the peacetime uses of the atom.

Atom: Instrument of Peace

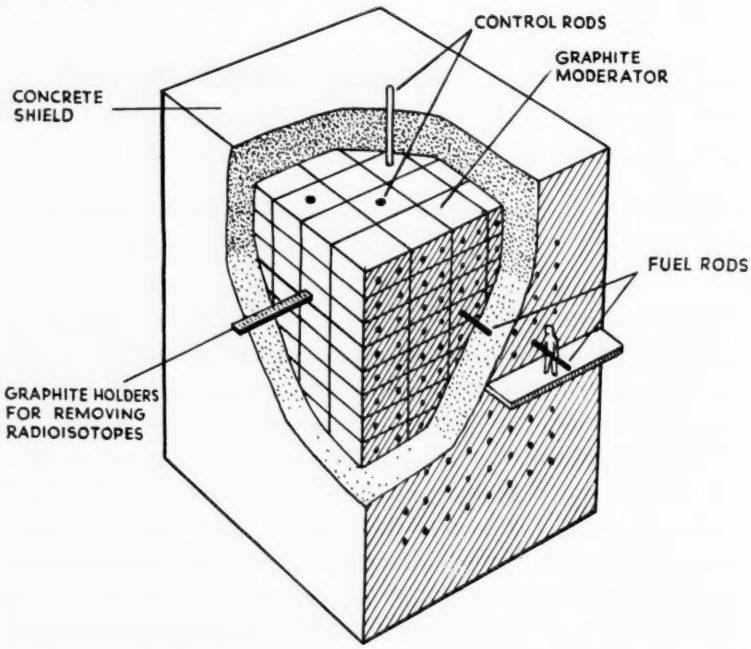
At Geneva the emphasis was on atomic power, although the peaceful uses of radioisotopes were not overlooked. The conference served the useful purpose of revealing the methods that had been developed or proposed in various countries to make the most effective use of the heat generated by fission, so that physicists of one country could appraise the achievements of their fellows in other countries. The whole technology of atomic power production was reviewed. Much that was well known was discussed; much that was new was disclosed. In the light of these discussions and disclosures the fundamental principles of power production by fission remain unchanged, but we now know that there are new ways in which the principles can be applied. Each way has its advocates.

What Kind of Reactor?

One subject of current debate is the reactor best adopted to peacetime purposes. The heat generated in a reactor is always converted into electricity. Which is the most efficient type of reactor or heat generator? No country has yet settled on a standard type, nor is any country likely to within the next ten years, if ever.

In the earliest and still the commonest form of reactor, rods of pure metallic uranium are thrust into blocks of graphite. Neutrons bombard the uranium metal within aluminum "cans" that contain the uranium. The graphite slows neutrons down from 600 to 60 miles a second so that they can split atoms of

REACTOR

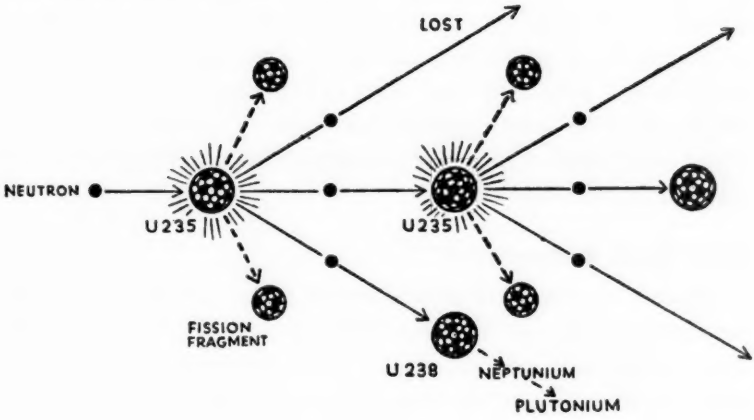


uranium-235. In the splitting more neutrons fly out (the number lies statistically between 2 and 3), and these in turn are slowed down by graphite to split more atoms of uranium-235.

This is known as a "chain reaction." To sustain a chain reaction, more than one neutron must be ejected from a struck atom of uranium-235. The uranium-238 in a reactor is not split by a chain reaction. It captures fast neutrons—a capture that results in the transmutation of some uranium-238 first into short-lived neptunium then into long-lived plutonium.

Both neptunium and plutonium are artificial elements. Plutonium is a fissile material which is just as good as uranium-235 for destroying a city or producing power. Reactors are a necessity because plutonium is made in them. In a type called a "breeder" actually more fissile material (plutonium) is produced than is consumed in the form of uranium.

FISSION CHAIN REACTION



What Is Atomic Heat?

The heat that is generated within a reactor is utilized just as engineers utilize the heat of a coal fire. A "coolant," as it is called, circulates within the reactor, the coolant being water, molten sodium, or a gas such as carbon dioxide. The circulating coolant, whatever it may be, goes to a heat exchanger, a sort of boiler, to boil other water and so raise steam, which goes to the usual turbine to drive the usual electric generator. Why one coolant, which may be water, and another lot of water that is to be boiled? Because the coolant is highly radioactive. By keeping it in a closed circulating system the water that is boiled to raise steam is not contaminated.

To stop or regulate the process of generating heat in the reactor, rods of boron or cadmium are needed. These rods control the flow of neutrons. The boron or cadmium rods are pushed in or pulled out to slow, accelerate or stop the chain reaction. Without control rods a reactor may run away. In fact a reactor may be regarded as an atomic bomb under control. Because of safety precautions it is only with difficulty that a reactor can be made to blow itself up; but the feat has been accomplished deliberately to find out what happens.

A reactor may be as small as a five-car garage or as big as a five-story building. Within that mass of concrete and steel is an inferno where uranium is silently but violently disrupted. Were it not for the shielding it would be fatal to approach a reactor within half a mile. After ten years of experience, man, the modern Prometheus who controls this inferno, is still awed, still elated, still terrified, when he considers what his knowledge and ingenuity have accomplished.

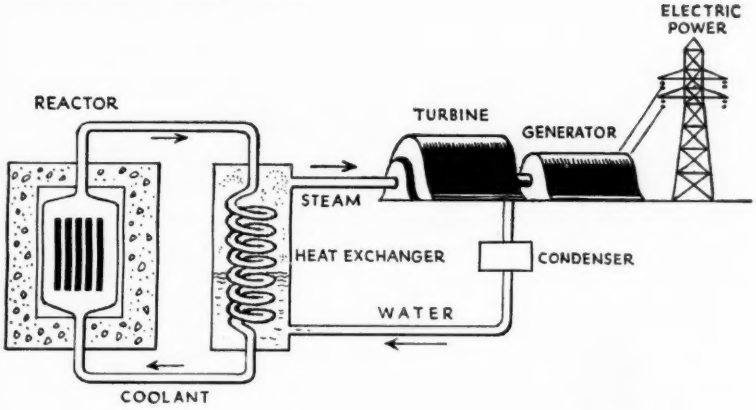
What About Radioactivity?

Another unsolved problem is that of radioactivity, the bane of the engineer who must design a power reactor. Deadly radioactive rays contaminate everything. They contaminate the water or other liquid which serves as a coolant and which is pumped to the heat exchanger, there to raise steam. They contaminate the walls of the reactor. They contaminate the aluminum cans in which the uranium rods or slugs are contained, the coil of pipe in which the coolant circulates, the coolant itself. Everything is contaminated. The time comes when the reactor must be virtually rebuilt. Moreover, every reactor must be associated with a chemical plant to purify contaminated, spent uranium. Somehow the absorption of too many flying neutrons must be reduced and, if possible, stopped. How that is to be done efficiently is one of the major tasks of the scientists who are trying to improve reactors.

Radioactivity complicates the disposal of fission products—the equivalent of "ashes" in ordinary furnaces. The "ashes" cannot be turned into streams because of the fish. A rat trapped in a reactor building cannot be buried because it may be dug up and eaten by some predatory animal which then becomes a menace to other animals.

A 100,000-kilowatt plant will produce about 200 pounds of highly radioactive fission products a year. Dr. S. A. Roger of the Argonne National Laboratories predicts that the day may not be very far off when it will be necessary to dispose of three tons of radioactive material in a day. This may seem no large amount; yet it must be diluted. To dilute all strontium-90 adequately—

NUCLEAR POWER PLANT



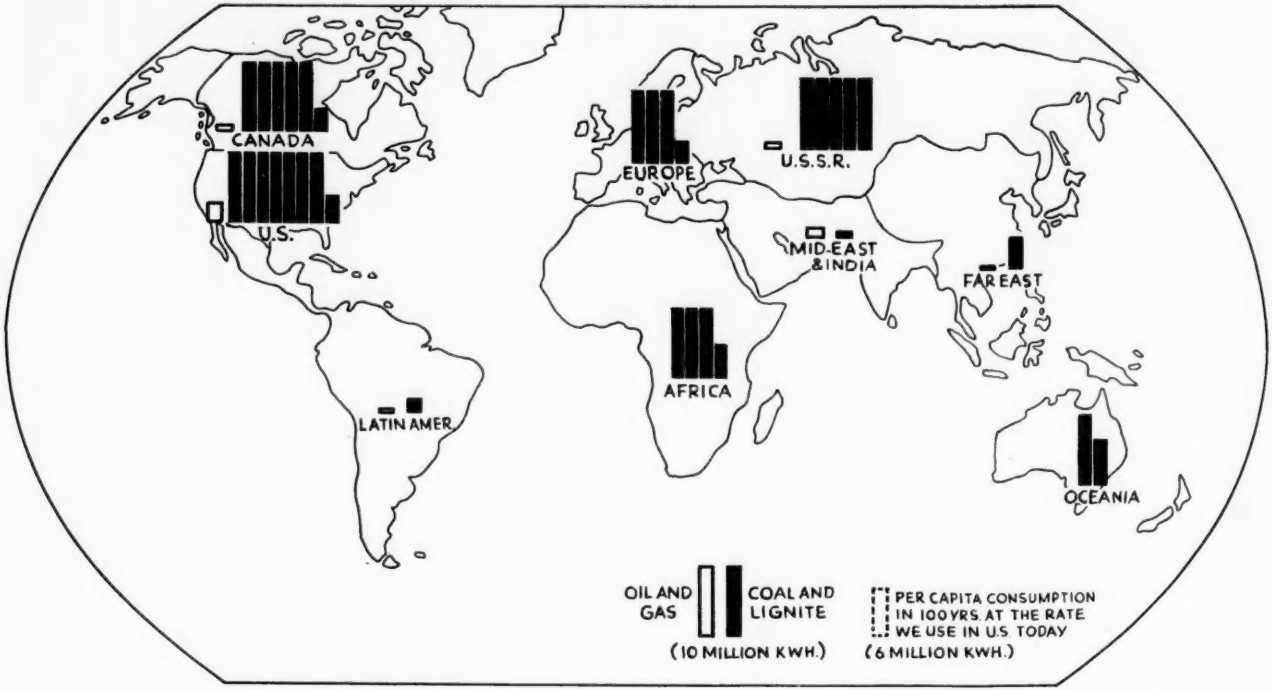
strontium is one of the most dangerous radioactive products of fission—would require about 5 percent of all the water in the oceans a century hence. Radioactive wastes have been buried in abandoned mines, and, properly encased in concrete, have also been dumped into the Irish Sea. At present it costs the Atomic Energy Commission from 35 cents to $2 a gallon to store fission products until they decay to a safe radioactive level.

Atomic Power Expensive —

Despite the difficulties that must be overcome in developing atomic power the United States, Britain and the U.S.S.R. have boldly engaged in experimentation. What are the prospects of success? With coal at $10 a ton and pure metallic uranium at $10,000 a pound, atomic power would cost too much even though a pound of uranium contains as much energy as 2 million pounds of coal.

The disposal of radioactive wastes, the purification of partially spent uranium-235, the maintenance of a plant in such condition that there will be no leak of radioactive coolant, the ceaseless medical vigilance required to guard against radiation sickness, account for much of the expense that must be incurred in operating an atomic power station. In the United States electricity is

PER CAPITA RESERVES OF COAL AND OIL



This map is based on a UN estimate of fuel reserves. To make the comparison possible, all fuel power—oil and coal—is translated into electric power. The two bars at the bottom of the map indicate 100 million KWH. The broken bar represents a yardstick, showing the amount one person in the United States consumes in 100 years.

generated with fuel at a cost estimated between 5 and 8 mills a kilowatt-hour. At first it will cost more, possibly twice as much more, to produce electric power with uranium or thorium. Nevertheless, the evidence is strong that in ten years or so it will be possible for an atomic power station to compete with a station which burns coal.

In appraising the possibilities of atomic power it must be borne in mind that of all the money spent by a central steam station, not more than 10 percent is needed for fuel. The rest goes for fixed charges (amortization, interest and the like), transmission lines, substations, distribution lines to customers, administration, bookkeeping, meter reading and service calls.

The substitution of atomic for combustible fuel will not alter this division of expense. In other words, the cost of fuel is not the most important item in the bill submitted by the electric light and power company to a customer. If the company paid nothing for coal, the bill would be reduced by only 10 percent. At present an atomic power station is a poor investment in the United States if we think only in terms of interest or dividends. But governments, physicists and economists are not thinking in such terms. They are thinking of the day when there will not be enough coal or oil to meet a growing demand for energy.

But It Is Essential

Perhaps the most careful recent estimate of the world's fuel reserves is that presented by Palmer C. Putnam in his book *Energy in the Future*. In about 50 years, he predicts, the world will find that it cannot satisfy its rapidly growing power needs with available fossil fuels, even though they will not be exhausted. By 1975 the atom will have to make good a significant power deficit. Atomic power may cost two or three times as much as coal, yet it must be developed if the rate of industrial expansion is not to be retarded, with all that retardation implies in lack of food and a lowered standard of living.

There is no doubt that the world will face a fuel crisis in 50 years or so. Even such countries as Switzerland and Sweden, which

amount one person in the United States consumes in 100 years.

now depend on hydroelectric energy, will not always be able to count wholly on falling water. Wind power, solar power and tidal power could be exploited, but even if they were, they could not make good a growing deficiency in coal, gas and oil.

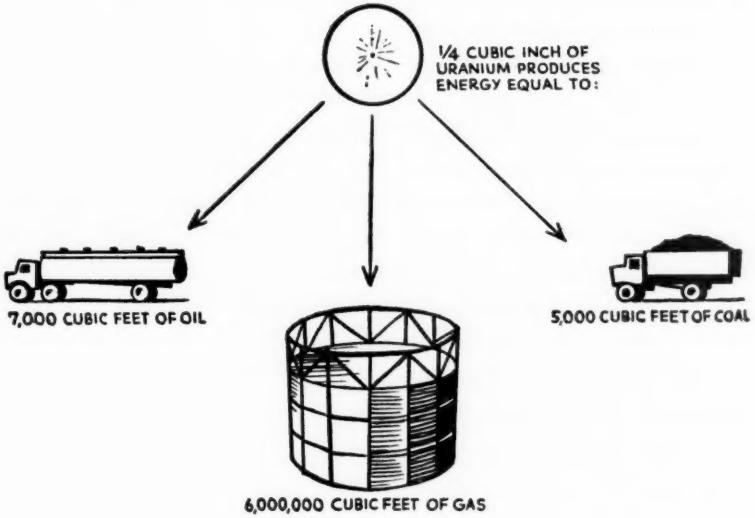
Britain already feels the need of more energy because its mines are no longer able to keep pace with the increasing consumption of coal. In a White Paper issued on February 1, 1955 the British government announced that in the next ten years it would build 12 nuclear power stations at a cost of $860 million. By the early 1970's the rate of construction of nuclear power stations should meet the total British need of new generating capacity, which will then amount to about 3 million kilowatts a year. On this assumption the total nuclear-power plant capacity installed in Britain by 1975 will be of the order of 10 million to 15 million kilowatts, and nuclear power stations will be producing electricity at a rate equal to that produced by about 40 million tons of coal annually.

What U.S. Is Doing

Although the United States is rich in coal, both the Atomic Energy Commission and private companies are actively engaged in developing atomic power. Proposals for the construction of power plants have been submitted to the commission by private utility companies, and the commission itself has a five-year reactor development program which should be carried out by 1958 at an estimated cost of $250 million.

The first commercial American atomic power station will be the one now being built at Shippingport, Pennsylvania, by the Westinghouse Electric Corporation at a cost of $46 million, of which the government is paying $33 million. The total cost of the station will be about $75 million if we include what has been spent on research and development. The Soviet Union has had in operation a 5,000-kilowatt industrial plant since June 1954—small as such plants go, but the world's first. Another Russian plant of 100,000-kilowatt capacity may be ready in 1956. Britain's first commercial atomic power plant (50,000 to 100,000 kilowatts)

ATOMIC ENERGY



will be in operation, possibly late in 1956 and certainly in 1957.

To the United States goes the credit of having built, launched and commissioned the first atomically driven submarine, the *Nautilus,* with another, the *Sea Wolf,* already launched. Both of these submarines can be driven at high speed under water for days and days. We have plans for an atomically driven airplane carrier, and there is even romantic gossip about atomically driven airplanes. Locomotives and transatlantic liners to be driven atomically could be built now at excessive cost. But how about automobiles? A 75-horse-power reactor for an automobile would require 55,000 pounds of shielding—more than the engine could propel.

If the Geneva atoms-for-peace conference is followed up, as it probably will be, by the United Nations, the countries which need atomic energy will be able in a few decades to make social and economic advances that would otherwise not have come about in a century. Atomic energy will not revolutionize folkways in the advanced West, but in Asia and the Middle East, in Russia,

Africa and Latin America large areas will undergo a revolution as far-reaching in its effects as was that which followed the introduction of the steam engine.

Change within science and technology is always followed by social change. The greater the scientific or technological change, the greater will be the social change. By this standard, the development of atomic power will not bring about any great social change in the West. For other areas of the world, however, the implications of atomic power are immeasurable. Atomic power, the only hope for tens of millions who now live precariously on a few handfuls of rice a day, must be developed as the first necessary step in the upward march to the kind of life that workers and farmers in Western Europe and the United States now regard almost as a birthright.

Talking It Over

ATOMIC ENERGY IS A SUBJECT WITH MANY FACETS. It has social, economic and political implications. The following topics are suggested for discussion at eight weekly meetings. If more meetings are considered necessary, thoughtful readers will find enough suggestions in the foregoing text. Unavoidably there is some overlapping in the eight topics listed below. If necessary, two topics can be discussed in one meeting. Reading references and suggestions for visual aids[1] are included under each topic.

Help or guidance in setting up a discussion group, and the special project described at the end of this section, will be given, on request, by Dorothy B. Robins, Consultant on Special Programs, Foreign Policy Association, 345 East 46th Street, New York 17, N.Y.

Discussion Questions

The literature on atomic energy is vast. Much of it is so highly technical that it is beyond the grasp of those who have not had rigorous training in mathematical physics, but much more is easily understood by anyone with a high school education.

For information on the social effect of discoveries in nuclear

[1] Unless otherwise noted, all films are 16mm, sound, and in black and white.

physics the best medium is *The Bulletin of the Atomic Scientists,* edited by Dr. Eugene Rabinowitch and published at 5734 University Avenue, Chicago 37, Illinois. The Federation of American Scientists, 1749 L Street, Washington 6, D.C., publishes weekly a *News Letter,* which comments briefly on legislation and state messages that are concerned with atomic energy and with important international proposals. The semiannual reports of the Atomic Energy Commission keep those interested in atomic energy abreast of current developments.

1. The Nature of Matter

It is impossible to discuss atomic energy, for whatever purpose it is used, without knowing something about the nature of matter and the meaning of such terms as "electrons," "protons" and "neutrons."

What is the atom? How did physicists of the mid-19th century think of it? How do physicists think of it today? What are isotopes? What has Einstein's theory of relativity to do with atomic energy?

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VISUAL AIDS

Atomic Physics. Produced by the J. Arthur Rank Organization, Ltd., England, and released in the United States by United World Films, Inc. 90 min. Rental, free, from local USAEC operations offices. An authoritative technical film on the history and development of atomic energy. The film is in five parts.

Atomic Energy. Produced by Encyclopaedia Britannica Films, Inc. 10 min. Rental, free, from local USAEC operations offices. An introduction to atomic principles.

2. Isotopes in Medicine, Biology, Agriculture and Industry

Every one of the 92 natural elements has its isotopes, that is, variants which differ from one another only in atomic weight. These isotopes are widely used by scientists to investigate life processes, to trace the course of elements in the living organism, to improve agricultural and industrial methods and to diagnose

and treat disease. How do isotopes create new plants and animals? How do scientists use isotopes to find out the way in which plants utilize fertilizers? How are isotopes applied in medicine? What are some of the industrial uses of isotopes?

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VISUAL AIDS

A Is for Atom. General Electric (all offices); 1953; 15 min.; color. Rental, free. An animated film explaining in lay terms what an atom is, how energy is released from certain kinds of atoms, and the peacetime uses of atomic energy and the by-products of nuclear fission.

Also available free from local USAEC operations offices are the following: *The Atom and Agriculture*, 10 min.; *The Atom and Industry*, 10 min.; *The Atom and the Doctor*, 12.5 min.; *The Eternal Cycle*, 12.5 min. (biological research); *The Atomic Greenhouse*, 12.5 min. (fertilizer research); *The Atomic Zoo*, 12.5 min. (livestock research).

3. Fission and Fusion

There are only two ways of releasing energy from the atom. One is by fission, that is, by breaking up the nucleus; the other is by building it up, or fusing two atoms of hydrogen together to form helium.

How was fission discovered? Why is energy obtained when two hydrogen atoms are fused? What limitations are imposed on the size of the fission bomb? Why are there no limitations to the size of a fusion bomb?

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VISUAL AIDS

Unlocking the Atom. Produced by United World Films, Inc. 20 min. Rental, free, from local USAEC operations offices. The purpose is primarily to acquaint students with the principles that govern the atom and its use. Describes chain reaction, atomic structure, properties of alpha, beta and gamma rays, operation of cyclotron, and contributions of various scientists.

4. International Control of Atomic Energy

Soon after the destruction of Hiroshima and Nagasaki efforts were made to control the use of atomic energy in war and peace. The two are inseparable because the method of producing atomic explosives is also the method of producing atomic power. The literature on the subject is enormous.

Such questions as these arise: How do the efforts to control atomic energy for military purposes of ten years ago contrast with those of today? What is the relation of the atomic bomb to disarmament? How does the Atomic Energy Act of 1946 compare with that of 1954?

What was the effect of the Geneva "summit" conference of 1955 and the Geneva International Conference on Peaceful Uses of Atomic Energy of 1955 in bringing about a better international understanding on the use of atomic energy in war and peace?

READING REFERENCES

The proceedings of the United Nations Atomic Energy Commission are important but much too voluminous for general reading. The final reports of the commission summarize what happened in the discussion of the Baruch proposals.

The speeches of members of the U.S. Atomic Energy Commission are good as interpretations of American policy. These go back ten years. Mimeographed copies can be obtained from the Atomic Energy Commission, Washington, D.C.

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Scientific American (a periodical), *Atomic Power.* Cited. See articles by Donald J. Hughes and Robert A. Charpie.

VISUAL AIDS

One World or None. Produced in 1946 by Association Films. 9 min. Rental, $4.00, from Association Films, Broad at Elm, Ridgefield, N.J. Develops the idea that there is no secret and no effective defense. Urges joint international action to prevent atomic war.

5. Prospects of Atomic Power

The world's population is growing so rapidly that by 1975 a power deficit will be noticeable. Food cannot be produced by methods at present known to feed all the world's population 50 or 100 years hence. In fact, a large part of the world does not get enough food now. An abundant source of power is essential.

What will be the world's power in 1975? What is the cost of atomic power at present? What will be the effect of introducing atomic power in countries that have no fuel resources and no water power? What are the United States, Britain and the Soviet Union doing to develop atomic power?

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VISUAL AIDS

Power Unlimited. Produced by the Handel Film Corporation. 12.5 min. Rental, free, from local USAEC operations offices. Tells the story of the development of nuclear power, with a complete account of the first generation of useful power by the Experimental Breeder Reactor at Arco, Idaho.

6. Genetics and Bombs

When an atomic bomb is exploded a great mushroom-shaped cloud burgeons miles into the air and carries with it dust and other fine particles which are radioactive. This debris is wafted by the wind for many miles before it is precipitated in what is called "fall-out."

It is known that X-rays and the rays given off by radioactive isotopes can change the heredity of plants and animals for better or worse. Why do geneticists fear that fall-out may have disastrous effects? What is the position of the Atomic Energy Commission? Should further tests of hydrogen bombs be forbidden by international consent?

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Much of the available material on the subject is contained in speeches and papers by Dr. Willard F. Libby, a member of the Atomic Energy Commission. These can be obtained in mimeographed form from the Atomic Energy Commission, Washington, D.C.

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Muller, H. J., "Is Radiation a Menace to Posterity?" *Science News Letter* (published by Science Service, Washington, D.C.), Vol. 55, Number 24, June 11, 1949. Also a paper by H. J. Muller which was to have been presented at the Geneva atoms-for-peace conference, August 1955, but was suppressed. Lewis L. Strauss, chairman of the Atomic Energy Commission, later apologized for the suppression. The paper will be published in the proceedings of the conference this year or next. Copies can be obtained from the United Nations.

The Effects of Atomic Weapons. Prepared for, and in cooperation with, the U.S. Department of Defense and the U.S. Atomic Energy Commission, under the direction of the Los Alamos Scientific Laboratory. Washington, D.C., USGPO, June 1950.

VISUAL AIDS

Bikini—Radiological Laboratory (A). Produced by the University of Washington for the U.S. Atomic Energy Commission. 22 min., color. Rental, free, from local USAEC operations offices. Three and a half years after the Bikini Able and Baker tests, scientists from the University of Washington make a survey of the effects of radioactivity on plant and marine life.

7. Effect of Atomic Weapons on Warfare

Atomic weapons are of two kinds, with modifications of each kind. Bombs, whether of the fission or fusion type, would be used strategically, that is, against industrial centers and large cities. There are also atomic shells that can be fired from artillery. These are tactical weapons that can be used on the battlefield.

Will atomic bombs and shells prevent war or act as a deterrent? Can all life be wiped out in an atomic war?

READING REFERENCES

Coale, Ansley J., *The Problem of Reducing Vulnerability to Atomic Bombs.* Princeton, N.J., Princeton University Press, 1947.

Lapp, Ralph E., *Must We Hide?* Cambridge, Mass., Addison-Wesley Press, 1949.

Lapp, Ralph E., *The New Force.* New York, Harper, 1953.

Morgenthau, Hans J., "Has Atomic War Really Become Impossible?" *Bulletin of the Atomic Scientists,* January 1956.

VISUAL AIDS

New Look at the H-Bomb. 10 min., 1955. Rental, free, from U.S. Federal Civil Defense Administration regional offices. Graphic explanation of the dangers of radioactive fall-out and preventive measures which can be taken for individual protection.

Also available: *Tale of Two Cities,* 20 min. (Hiroshima and Nagasaki), U.S. Army Headquarters Film Libraries, free; *Special Delivery,* 12 min. (Air Force participation in Bikini tests), U.S. Air Force Headquarters Film Libraries, free; *Operation Crossroads,* 27 min., color (two Bikini tests), U.S. Navy Headquarters Film Libraries, free; *Operation Greenhouse,* 25 min., color (blast and thermal effects on structures, aircraft, etc., at Eniwetok test), USAEC local offices, free; *Operation Doorstep,* 10 min. (Nevada test on vehicles, houses and dummies), Federal Civil Defense Administration regional offices, free.

8. Obstacles to Exploiting Atomic Power

Military thinking has hampered engineers and private companies in developing atomic power. What are some of the obstacles that must be removed? How does atomic power compare in cost with power from combustibles in the United States? or in Britain?

How is the heat generated in a reactor converted into electric power? What is the relation of fuel costs to the retail price of electricity?

READING REFERENCES

"Atomic Power—A World Picture." *UNESCO Courier,* Vol. VII, No. 10, March 1955. A special issue in which 14 articles give the facts and prospects of atomic energy for power production.

Panel on the Impact of the Peaceful Uses of Atomic Energy, *Peaceful Uses of Atomic Energy*. Report to the Joint Committee on Atomic Energy. Cited.

Woodbury, David O., *Atoms for Peace*. New York, Dodd, 1955.

Atomic Energy Exhibit

The preparation of exhibits on atomic energy by high school or college science students offers an excellent class project. The results may also prove valuable in the educational work of community organizations which may wish to use the exhibit in meetings or conferences on the uses of atomic energy or sponsor the display of exhibit items at a central location in the community.

The exhibit may include such items as (1) large circuit-type or flow chart diagrams of various reactor types; (2) explanation through text and/or diagram of how radioisotopes are produced and used; (3) charts on application of atomic heat for nonpower uses; (4) model in wood, plastic or plaster of an atomic reactor.

Information and technical aid for the preparation of such exhibits may be obtained from a number of sources, including (1) The Atomic Energy Commission, Washington, D.C.; (2) The Atomic Industrial Forum, Inc., 260 Madison Avenue, New York, N.Y.; (3) The American Museum of Atomic Energy, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee; (4) certain technical and semitechnical publications in the field, such as the monthly *Nucleonics;* (5) private companies active in the atomic energy field, such as General Electric, Westinghouse, and others.

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